On the Place of a Star near the Variable RU Herculis. (Correction to former paper.) By F. A. Bellamy.

In a letter, Fr. Hagen has kindly drawn attention to a discrepancy between his observation and the position of star No. 19 as given in my paper (*Monthly Notices*, lxii. p. 75). Upon examination the cause was found to be in the transcription from the original measure sheets to the computation forms preliminary to conversion of measured coordinates to R.A. and Dec. : the line of figures opposite star No. 19 should read thus :—

19	11·0	8·3363	5·6320	$6^m\ 16^s{\cdot}76$	$23'\ 7''{\cdot}4$

The computations have been examined for the other stars but no further errors were found.

On Mr. Love's Formula for the Wave-Lengths of Nebular Lines. By W. H. Wright.

(*Communicated by the Secretaries.*)

In the May number of the *Monthly Notices* of the Royal Astronomical Society, Mr. E. F. J. Love publishes a note on a relation which he considers to exist among the wave-lengths of some of the nebular lines. The supposed law, expressed in the general form adopted by Runge and others in their work on line series in the spectra of some of the elements, is as follows :

$$\lambda^{-1} = 25739 + 43108\, n^{-2} - 1412208\, n^{-4} \qquad \ldots \qquad \ldots \qquad (1)$$

Such a law would be of the greatest interest and importance, not only by virtue of the fact that it would bring another spectrum into the line-series class, but also on account of the light it would shed on the composition of the nebulæ by correlating a certain number of the "unknown" lines, and indicating their common origin. But, great as is the desideratum for such an expression of relation, the writer is inclined to doubt that any physical significance attaches to Mr. Love's formula. A number of reasons for this point of view will be given as briefly as possible.

In the following table the values of λ as determined from equation (1) are tabulated with n as argument :

Table I.

n	λ computed.	λ in nebulæ.
3	7637·0	not observed.
4	4363·6	4363·3 } Used to deduce the formula.
5	3967·6	3967·6 }
6	3868·9	3868·9 }
7	41·6	not observed.
8	36·1	3836* (Campbell).
9	37·9	not observed.
10	41·9	3842 (Huggins).
11	46·3	not observed.
12	50·6	not observed.
13	54·4	3854 (Huggins).

By assuming $n = 11·5$ and $14·5$, additional approximate coincidences are secured with two of the lines observed by Huggins.

Let us examine somewhat critically the identities assumed by Mr. Love, as given in column three of the above table. As he points out, it is hardly probable that a line at λ 7637 would be observed in a nebular spectrum, supposing it were present. The agreement of the next three wave-lengths should follow as a matter of necessity, as they were used in computing the constants of the formula. Owing, however, to some slight numerical error, there is a discrepancy of 0·3 tenth-metre between the observed and computed values of the line λ 4363. Just what effect the correction of this error would have on the computed wave-lengths I have not determined. It is probable that the change would not amount in any case to more than one unit.

Passing for a moment the identification of the value $n = 8$, we come to the lines observed by Huggins. With regard to them it may be said that they are only a few of a group reported by that observer as existing in this region of the spectrum. The entire group is as follows : $\lambda\lambda$ 3896, 3887, 3878, 3870, 3859, 3854, 3848, 3842, 3832 and 3825. Under the circumstances some apparent coincidences are to be expected. Attention should moreover be called to the fact that there appears to be a systematic difference between Huggins's determinations and my own (from which the constants of Mr. Love's formula were computed) amounting to about $+2·5$ tenth-metres (W—H). This difference was determined from the three lines $\lambda\lambda$ 5007, 4959, and 3727, and is partly to be accounted for by the difference between the Angström and Rowland scales, amounting

* The wave-length published by Campbell is λ 3835. The wave-length given in the table is the one assumed by Mr. Love in his discussion.

in this region to about 0·8 tenth-metre. The reason for the choice of these particular lines is that they are the only lines measured by both Sir William Huggins and myself concerning which assumptions could not be made as to wave-length. The other lines measured by both observers were by each assumed to be due to hydrogen, and cannot therefore be used for the present purpose. Assuming that the difference +2·5 affects the group of lines under discussion, the coincidences in Table I. are destroyed. There is, however, a line in the group at λ 3848, and applying the correction we have a coincidence with the value 3850·6 corresponding to $n = 12$, a fact which indicates, perhaps, as much as anything else, the likelihood of occasional coincidences in a case of this sort. It should further be stated that the group of lines mentioned was observed only on the much discussed 1888 negative secured by Sir William and Lady Huggins. This photograph was taken fourteen years ago, and, although its indications were of remarkable interest, they have not since been confirmed, though attempts were made by several observers—notably Keeler, Campbell, and Huggins himself—to repeat the observations.

The only coincidence, then, to be taken seriously is that of λ 3836. This line has been identified by Campbell and others as $H\eta$ (λ 3835·6), and there is little reason to doubt that the identification is correct. It is one of a series of lines in the spectrum of the *Orion* nebula, the members of which decrease regularly in intensity towards the violet, and agree, within the limits of observational error, with the lines of the well-known hydrogen series. In Table II. are the wave-lengths as measured by Campbell in the nebular spectrum, and by Ames in the spectrum of hydrogen.

Table II.

Nebulæ.	Hydrogen tube.	Nebulæ.	Hydrogen tube.
4861	4861·5	3835	3835·6
4341	4340·6	3798	3798·0
4102	4101·9	3770	3770·7
3969	3970·2	3749	3750·2
3889	3889·2		

The wave-length λ 3969 in the nebular spectrum is of course that of the centre of gravity of the doublet λλ 3967·6 and 3970·2, which accounts for the apparent discrepancy shown by the table. λ 3749 is marked by Campbell as "very faint," and was therefore probably a difficult line to measure. In this case the residual is slightly over a tenth-metre, while in all the others the residuals are less than this amount. It is then difficult to interpret Mr. Love's statement, made in substantiation of his belief that "the hydrogen series beyond $H\epsilon$ has probably not yet been detected in nebular spectra," to the effect that he

finds it "much easier to believe some of Campbell's identifications wrong than to believe that his measurements are incorrect by three and four tenth-metres." Campbell's measurements seem to the writer to constitute a proof that the ultra-violet hydrogen series has been observed in the *Orion* nebula as far as Hκ, and that the line λ 3835 is due to hydrogen. But, however that may be, evidence is not lacking that the line does not belong to a series including $\lambda\lambda$ 4363, 3968, and 3869. The line in question does not appear to vary in intensity in a regular manner with the latter lines, unless indeed the relation be an inverse one. The line λ 3835 and those in Table II. to the violet of it have been observed only in the *Orion* nebula, an object in which the hydrogen lines are unusually bright, and the three lines mentioned comparatively faint. It is in the planetary nebulæ, in which the line λ 3835 is too faint for observation, that the three lines taken by Mr. Love as the basis of his series are bright.

In view of the above facts the writer considers that there is not a single coincidence between computed and observed wavelengths upon which the proposed formula can be considered to rest.

The writer considers it very doubtful whether λ 4363 is emitted under the same conditions as $\lambda\lambda$ 3968 and 3869. The latter lines are of about the same intensity in a number of different nebulæ,* but the intensity of λ 4363 appears to vary relatively to them more than can be accounted for by instrumental considerations. So far as the three corresponding *Nova* bands being characterised by an identity of structure is concerned, the observations made at the Lick Observatory show the structure of all the brighter lines to be pretty much the same.

Lick Observatory: 1902 *August.*

Explanation of Use of Tables of $\frac{1}{2}(\theta + \cos\theta)$.

By W. Steadman Aldis, M.A.

The equations connecting the eccentric, true, and mean anomalies, and radius vector in an elliptic orbit are

$$(1)\qquad m = u - e\sin u\,;$$

$$(2)\qquad \tan\frac{v}{2} = \sqrt{\frac{1+e}{1-e}}\tan\frac{u}{2}\,;$$

$$(3)\qquad r = a(1 - e\cos u).$$

* Lick Observatory Bulletin, No. 19.